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Contaminated Sediment Management Guide for NSRP Shipyards

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

in cooperation with
National Steel and Shipbuilding Company
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Contaminated Sediment Management Guide for NSRP Shipyards

A Final Report for N1-96-02
Follow the Development and Analyze the Impact of the Federal Guidelines for Sediment Management

Prepared by
National Steel and Shipbuilding Company

July 1999

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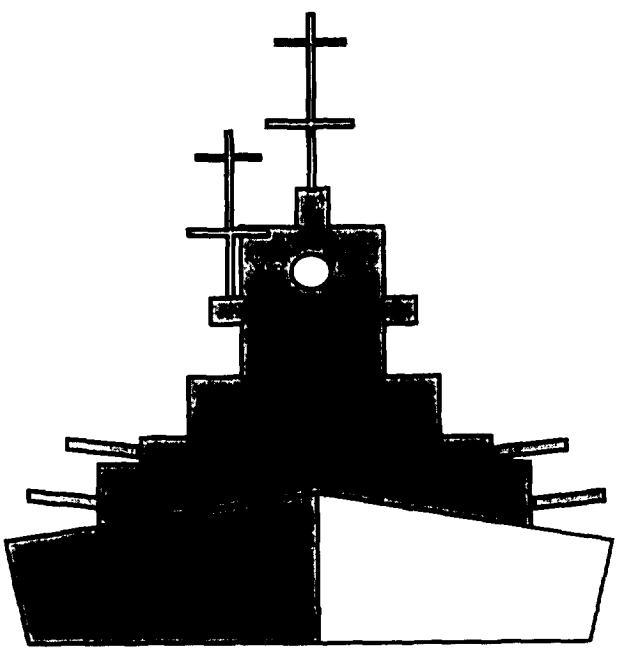


I. Contaminated Sediment & Shipyard Operations

1. Introduction

Contaminated sediments are soils, sand, organic matter, or minerals that accumulate on the bottom of a water body and contain toxic or hazardous materials that may adversely affect human health or the environment.

The United States Environmental Protection Agency (EPA) estimates that about 10 percent of the sediment underlying U.S.' lakes, rivers, and bays is sufficiently contaminated with toxic chemicals to pose potential risks. These toxic chemicals can kill the aquatic lives that live in those waters or impair the health of people and wildlife that eat contaminated fish.

EPA began documenting the extent and severity of sediment contamination through the surveys conducted in 1985 and 1987. The surveys found that heavy metals and metalloids (e.g., arsenic), PCBs, pesticides, and polycyclic aromatic hydrocarbons (PAHs) are the most frequently reported contaminants in sediments.

In 1990, EPA was requested to create a national program to address contaminated sediments. The request was made by the National Contaminated Sediments Working Group, a coalition of 13 environmental advocacy groups.

The Water Resources Development Act of 1992 requires EPA to compile all existing information on the quantity, chemical and physical composition, and geographic location of pollutants in sediments, including the probable sources of such pollutants. EPA's Office of Science and Technology (OST) initiated the biennial National Sediment Quality Survey Report to Congress. In 1997, EPA completed the Report to Congress, *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* in four volumes. This is the first EPA analysis of sediment chemistry and related biological data to determine the national incidence and severity of sediment contamination. The analysis of the sediment quality data indicates that potential sediment contamination exists in all regions and states of the country. The waterbodies affected include streams, lakes, harbors, near shore areas, and oceans. The results of the EPA analysis are consistent with the findings of other national assessments of sediment contamination.

In March 1992, EPA released the draft Contaminated Sediment Management Strategy outline and solicited written comments. The proposed Contaminated Sediment Management Strategy was announced for public comment in the August 30, 1994, Federal Register. In April 1998, EPA released the *Contaminated Sediment Management Strategy*. The goals of EPA's Contaminated Sediment Management Strategy are: 1) to prevent further contamination of sediments that may cause unacceptable ecological or human health risks; 2) when practical, to clean up existing sediment contamination that adversely affects the Nation's water bodies or their uses, or that causes other significant effects on human health or the environment; 3) to ensure that sediment dredging and the disposal of dredged material continue to be managed in an environmentally sound manner; and 4) to develop and consistently apply methodologies for analyzing contaminated sediments.

EPA can take actions directed at remediation of contaminated sediments under the authority of the Comprehensive Emergency Response, Compensation and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), the Clean Water Act (CWA), the Toxic Substances Control Act (TSCA), the Rivers and Harbors Act, the Oil Pollution Act, and the Water Resources Development Act (WRDA).

Much of the contaminated sediment in the US was polluted by now banned or restricted chemicals such as DDT, PCBs, and mercury. However, because of the physical proximity of shipyards to water bodies and their activities taking place over water or near shore locations, the potential risks of contaminating the underlying sediments by shipyards are commonly believed to present. Direct discharges of hazardous and toxic materials from floating drydocks, graving docks, ways, and marine railways are perceived to pose the primary risk of contaminating sediments.

Therefore, the impact that the proposed Contaminated Sediment Management Strategy (1994) and EPA's other associated regulatory activities would bring to shipyards upon their implementation needed to be examined. The NSRP Project N1-96-02, *Follow the Development and Analyze the Impact of the Federal Guidelines for Sediment Management,* was awarded: 1) to follow the development of the EPA Contaminated Sediment Management Strategy and other sediment management related activities; 2) to identify the impacts on the shipbuilding and repair industry, and 3) to develop a Contaminated Sediment Management Guide for NSRP Shipyards.

2. N1-96-02 – Follow the Development and Analyze the Impact of the Federal Guidelines for Sediment Management

The objectives of this project were to follow EPA's sediment management regulatory development activities for their potential impacts on the shipbuilding and repair industry and prepare a guidance document for NSRP shipyards.

To achieve the above objectives the project was divided into four tasks. Task One involved reviewing, evaluating, and documenting EPA's progress. Task Two involved surveying shipyards for assembling data on sediment contamination. Task Three involved identifying and analyzing the remedial alternatives that shipyards have available during the assessment, cleanup, and disposal of contaminated sediments. Task Four was to produce a guidance document to assist shipyards in identifying and managing contaminated sediment.

3. EPA's Contaminated Sediment Management Strategy Regulatory Progress

EPA has the authority under many federal statutes to address contaminated sediments. These federal statutes include the National Environmental Policy Act (NEPA); the Clean Air Act (CAA); the Coastal Zone Management Act (CZMA); the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); the Marine Protection, Research, and Sanctuaries Act (MPRSA); the Resource Conservation and Recovery Act (RCRA); the Toxic Substances Control Act (TSCA); the Clean Water Act (CWA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); and the Great Lakes Critical Programs Act of 1990.

Many EPA offices implement these statutory authorities or coordinate implementation in specific geographic areas, including through the Chesapeake Bay Program, the Great Lakes National Program, the Gulf of Mexico Program, the Washington State Sediment Management Standards Program, and the Sates of, California, Florida, Massachusetts, New Jersey, New York, South Carolina, Texas, Washington, and Wisconsin.

However, Implementation of these programs by various EPA program offices has created inconsistencies in procedures for assessing the relative risks posed by contaminated sediment and has increased the potential for duplication of efforts in areas of research, technology development, and other activities.

EPA formed an Agency-wide Sediment Steering Committee to address the problem of contaminated sediments on a nation scale in 1989. In 1990, the Committee then decided to prepare an Agency-wide Contaminated Sediment Management Strategy to coordinate and focus EPA's resources on contaminated sediment problems. In March 1990, EPA was requested to create a national program to address contaminated sediments. The request came from the National Contaminated Sediments Working Group, which was a coalition of 13 environmental advocacy groups.

Also, the enactment of the Water Resources Development Act (WRDA) in 1992 mandates EPA to conduct a comprehensive national survey of data regarding sediment quality in the US. EPA is required to compile all existing information on the quantity, chemical and physical composition, and geographic location of pollutants in sediments, including the probable sources of such pollutants. WRDA further requires EPA to: 1) identify the location of pollutants in sediments; 2) identify the extent of pollutants in sediments determined to be contaminated; 3) establish methods and protocols for monitoring the effects of contaminated sediments and the pollutants therein; 4) develop a system for the management, storage, and dissemination of data concerning sediment quality; 5) provide an assessment of sediment quality trends over time; 6) identify locations where pollutants in sediments may pose a threat to the quality of drinking water supplies, fisheries resources, and marine habitats; and 7) establish a clearinghouse for information on technology, methods, and practices available for the remediation, decontamination, and control of sediment contamination. The results are to be reported to Congress biennially starting four years from the date of enactment of WRDA. In 1997, EPA completed the first Report to Congress on the findings of the survey.

Concerns and efforts related to contaminated sediment have resulted in EPA's publication of over 30 sediment-related documents with another 15 documents in work. **Appendix 1: Index of Documents Related Sediment Management** in this Guide illustrates the status of these documents. Of those documents, the following topics pose great interest and concerns to shipyards.

a. Contaminated Sediment Management Strategy (EPA 823-R-98-001)

The EPA Office of Water released Contaminated Sediment Management Strategy in April 1998. The document describes specific actions that EPA would take to reduce environmental and human health risks associated with contaminated sediment. The Strategy does not propose new regulations and is defended as EPA's acting under existing regulatory authority to implement policies that would assess, prevent, and remediate contaminated sediment. EPA contends that Contaminated Sediment Management Strategy was developed to streamline decision-making within and among EPA's program offices. EPA intends to achieve streamlining by promoting and ensuring the use of consistent sediment assessment practices, consistent consideration of risks posed by contaminated sediment, the use of consistent approaches to managing contaminated sediment risks, and the proper use of resources for research and technology development.

The Strategy sets forth four specific goals that EPA intends to achieve. They are: 1) to prevent the volume of contaminated sediment from increasing; 2) to reduce the volume of existing contaminated sediment; 3) to ensure that sediment dredging and dredged material disposal are managed in an environmentally sound manner; and 4) to develop scientifically sound sediment management tools for use in pollution prevention, source control, remediation, and dredged material management.

The Strategy is comprised of six component sections: assessment, prevention, remediation and enforcement, dredged material management, research, and outreach.

1. Assessment

All EPA program offices will use consistent chemical criteria and biological test methods to determine if sediment is contaminated. EPA has published four acute test methods as standard methods for assessing contaminated sediment. EPA is in the process of developing standard chronic toxicity test protocols for two species of freshwater organisms and one marine species. The four acute test methods are:

- Ten-day freshwater acute toxicity tests using Hyalella azteca (amphipod or scud) and Chironomus tentans (midge).
- Twenty-eight day freshwater bioaccumulation tests using Lumbriculus variegatus (freshwater oligochaete worm).
- Ten-day marine and estuarine acute toxicity tests using the ampipods Ampelisca abdita, Rhepoxynius abronius, Hyalella azteca, Eohaustorius estuarius, and Leptocherius plumulosus.
- Twenty-eight day marine bioaccumulation tests using Macoma nasuta (clam) and Neries spp. (polychaete worm).

EPA program offices originally intended to use sediment quality criteria, upon publication, to assess contaminated sediment sites. However, the agreement between EPA and the U.S. Army Corps of Engineers have resulted in change of EPA's original intent. EPA will no longer issue sediment quality criteria, instead, will develop equilibrium partitioning sediment guidelines (ESGs) (see Equilibrium Partitioning Sediment Guidelines below for more detailed information). EPA will also use the National Sediment Inventory as a screening-level assessment tool to identify potentially contaminated sediment sites for consideration for remedial and enforcement actions and to identify toxic substances requiring further regulation, and to identify watersheds for nonpoint source management practices.

2. Prevention

EPA will propose acute sediment toxicity tests be included to support pesticide registration and re-registration. EPA will also propose incorporating acute sediment toxicity tests and sediment bioaccumulation tests into routine chemical review processes required under TSCA. EPA will negotiate enforceable settlement agreements that require source recycling and source reduction activities.

EPA will work with non-governmental organizations and the States to prevent point and nonpoint source contaminants from accumulating in sediments. EPA will promulgate new and revised technology-based effluent guidelines for industries that discharge sediment contaminants. EPA will encourage the States to use biological sediment test methods and equilibrium partitioning sediment guidelines (ESGs) for interpretation of water quality standards and to develop Total Maximum Daily Loads (TMDS) for impaired watersheds.

EPA will use the National Sediment Inventory to identify point sources of sediment contaminants for permit compliance tracking and to identify watersheds where technical assistance grants would reduce non-point source loads of sediment contamination. EPA will ensure that discharges from CERCLA sites and RCRA facilities subject to NPDES permits comply with future NPDES permit requirements. EPA will also consider sediment contamination as a factor to determine which industries should be subject to new and revised effluent guidelines, to use pollution prevention policies to reduce or eliminate sediment contamination, to develop guidelines for design of new chemicals, and to implement point and non-point source controls.

3. Remediation & Enforcement

EPA will use the National Sediment Inventory to target sites for enforcement action requiring contaminated sediment remediation. EOA will also use standard sediment toxicity, bioaccumulation tests, and site-specific field-based methods for identifying remediation, determining clean-up goals, and monitoring the effectiveness of remedial actions.

EPA will use multiple statutes (CERCLA, RCRA, CWA, TSCA, the Rivers and Harbors Act, and the Oil Pollution Act) to require contaminated sediment remediation by parties responsible for pollution. On a site-specific basis, EPA will consider natural attenuation as a remedy.

4. Dredged Material Management

EPA will continue to collaborate with the United States Army Corps of Engineers (COE) to ensure an environmentally sound management of dredged materials. EPA and COR released *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. – Testing Manual* in February 1998. This document is commonly referred to as the "Inland Testing Manual" (ITM). The purpose of this document is to provide guidance on evaluating proposed discharges of dredged materials into wasters of the US. However, the technical methods described in this document are not generally suitable for, and are not intended to apply to, dredged material resulting from landclearing and ditching activities. The methods are not generally suitable for, and not intended to apply to, the evaluation of dredged material discharges to uplands or to waters of the US that are not typically inundated. This manual was to be phased in over the 18 months from the February 1998 release date. This document replaces the 1976 *Ecological Evaluation of Proposed Discharge of Dredged or Fill Material into Navigable Waters.*

5. Research

EPA will continue to collect new chemical and biological data on sediment quality to be included in the National Sediment Quality Survey. EPA will develop new biological methods to assess the ecological and human health effects of sediment contaminants and data for ESGs. EPA will develop sediment toxicity identification evaluation procedures that can help guide the selection of appropriate remediation strategies, augment post-remediation monitoring, and be used for determining factors for ecological risk assessment. EPA will also develop dredged material disposal fate and transport models, sediment wasteload allocation models, and technologies for remediating contaminated sediment.

6. Outreach

EPA will undertake a program of outreach and technology transfer to educate other Federal agencies, State and local agencies, the regulated community, the scientific community, environmental advocacy groups, the new media, and the general public on issues concerning contaminated sediment risk management.

b. Equilibrium Partitioning Sediment Guidelines (ESG)

Over the past 15 years, a research team from the US EPA Office of Water and the Office of Research and Development has investigated the toxicity and bioavailability of sediment contaminants to benthic organisms. As a result of the research, EPA proposed in 1993 the guidance document *Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contamination for the Protection of Benthic Organisms by Using Equilibrium Partitioning Theory (EPA-822-R-93-011)* that established the foundation for developing sediment quality criteria (SQC). EPA also released *Guidelines for Deriving Site-Specific Sediment Quality Criteria for the Protection of Benthic Organisms (EPQ-822-R-93-017).*

The Equilibrium Partitioning Theory (EqP) is an approach to identify and quantify the bioavailability and toxic fraction of the chemical constituent. The EqP presumes that a chemical partitions into a state of equilibrium among the sediment organic carbon, the organism lipid, and the pore water based upon the volatility of the chemical contaminant. The validity of this approach has been shown in laboratory and field experiments.

In 1994, EPA released documents with proposed SQC for five chemicals (acenaphthlene, dieldrin, endrin, fluoranthene, and phenanthrene). After considering public comments on the SQCs for five chemicals, EPA decided not to release SQC for acenaphthlene, fluoranthene, and phenanthrene. The SQC for dieldrin and endrin and the two above-mentioned documents are scheduled for release as final in the fall of 1999.

Also, additional research has been conducted on the toxicity and bioavailability of polycyclic aromatic hydrocarbons (PAHs). However, because PAHs occur most often as mixtures in sediments rather than as single chemicals, EPA has continued to investigate the toxicity of PAH mixtures in sediment. The empirical model for predicting the toxicity of PAH mixtures was presented to the Science Advisory Board (SAB) in 1997. The objectives of the SAB consultation were to evaluate the proposed approach, identify remaining issues that require further investigation, and determine whether it is reasonable to pursue the development of an SQC for PAH mixtures. The SAB agreed that SQC for individual PAH compounds would be "underprotective" in practice, that more meaningful guidance for PAHs should be based on total PAHs, and that the proposed approach using EqP was a significant advancement in the evaluation of PAHs in sediment. EPA is currently working on releasing a final draft on the PAH mixtures ESG (see below) in the summer of 1999.

EPA has also developed a sediment guidance document to address mixtures of metals in sediments. This document was reviewed by the SAB in 1995; and recommendations from the review have been addressed. In 1999, EPA presented the metal mixture ESG (see below) to the SAB panel. The Metal Mixtures ESG addresses the toxicity of six metals (cadmium, copper, lead, nickel, silver, and zinc). EPA is currently incorporating chromium toxicity information and a proposed means to predict toxicity using the fraction organic carbon into the document. A finalized Metal Mixtures ESG document is expected by fall 1999.

EPA originally proposed SQC for use in assessing contaminated sediments, adopting as water quality standards, and developing Total Maximum Daily Loads (TMDL) for impaired watersheds in 1995. Since then, EPA and the US Army Corps of Engineers have resulted in agreement on the intended application and implementation of EPA sediment guidelines. In keeping with this agreement, as well as to provide greater flexibility to states, tribes, and the regulated community, EPA will no longer be issuing SQCs. Instead, the Equilibrium Partitioning Sediment Guidelines (ESGs) will be developed. The application and implementation of ESGs will be described in the document *Implementation Framework for Use of Equilibrium Partitioning Sediment Guidelines,* which is anticipated for release in fall 1999.

c. National Sediment Inventory

In July 1996, EPA released the draft documents, The National Sediment Quality Survey: a Report to Congress on the *Extent and Severity of Sediment Contamination in Surface Waters of the United States (EPA0823-D-96-002)* and *the National Sediment Contaminant Point Source Inventory: Analysis of Facility Release Data (EPA-823-D-96-001).* The reports were to Congress as required under the 1992 Water Resources Development Act of 1992. The Act required that EPA, in consultation with the National Oceanic and Atmospheric Administration (NOAA) and the US Army Corps of Engineers, conduct a comprehensive national survey of data regarding sediment quality; identify locations of sediments that are contaminated and probable sources of pollution; report to Congress the findings, conclusions, and recommendations every two years; and, develop a system to manage, store, disseminate sediment quality data.

The documents were renamed, *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* and were revised into a four volume document. Volume one through Volume three were released as final documents in September 1997, and Volume four is under development and does not have a proposed release date yet. The four volumes are:

- *Volume 1: National Sediment Quality Survey (EPA 823-R-97-006)* – Assesses the probability of associated adverse human or ecological effects with contaminated sediment based on a weight-of-evidence evaluation
- *Volume 2: Data Summaries for Areas of Probable Concern (EPA 823-R-97-007)* – Presents sampling station location maps and chemical and biological summary data for watersheds containing areas of probable concern
- *Volume 3: National Sediment Contaminant Point Source Inventory (EPA 823-R-97-008)* – A screening analysis that identifies probable point source contributors of sediment pollutants
- *Volume 4: National Sediment Contaminant NonPoint Source Inventory* - not yet released)

The Report is EPA's first comprehensive national survey of contaminated sediments and represents the largest set of sediment chemistry and related biological data ever complied into a national database. The report compiles over two million records of sediment analyses taken from 21,000 stations across the country between 1980 and 1993.

EPA uses the National Sediment Inventory data to classify the sediment quality at each station into one of three tiers. In Tier 1, the adverse effects are probable. In Tier 2, they are possible but infrequent. In Tier 3, there is no indication of adverse effects. If a watershed contains 10 or more Tier 1 stations, and at least 75% of its stations are either Tier 1 or Tier 2, the watershed is classified as an area of probable concern. According to the report, about 12% of the sediment in US watersheds is contaminated and lists 96 watersheds as having "probable concern" where human and aquatic health are at risk.

EPA notes that areas of sediment contamination occur in coastal and inland waterways, in clusters around larger municipal and industrial centers, and in regions affected by agricultural and urban runoff. PCBs, mercury, organochlorine pesticides, and PAHs are the most frequent chemical indicators of sediment contamination in Tier 1. EPA traces much of the contamination to the era of widespread use of DDT, PCBs, and mercury. These chemicals can persist for many years in sediment and are a continuing source of environmental concern.

EPA's recommendations based on the report call for further state and federal evaluation of the 96 watersheds, particularly those segments with 10 or more Tier 1 sampling stations. EPA restates in the report its contaminated sediment management strategy goals to reduce the existing volume of contaminated sediment and to prevent an increase in volume of contaminated sediment.

The next report is due in the year 2000 and will rely on test data from the 1990s that may confirm sediment quality is improving. EPA suggests that recent bans on many chemicals have already improved water quality in many watersheds, thus, the improvement in sediment quality is probable.

d. National Sediment Contaminant Point Source Inventory

The volume three of the Report to Congress is an inventory of sources of sediment contamination, hereafter being referred to as the Source Inventory. EPA contends that the Source Inventory will be useful to: identify sites where additional evaluation is necessary for a determination of adverse effects; identify industrial categories potentially contributing sediment contaminants to surface waters; and select industries for the development of effluent guidelines on the basis of quantities of potentially toxic sediment contaminants discharged.

EPA used more than 25,500 individual Toxic Release Inventory (TRI) and Permit Compliance System (PCS) chemical release data from 1993 and 1994, respectively, for the Source Inventory. EPA developed and employed a screening-level hazard analysis based on chemical and facility-specific releases, physical and chemical properties, and potential environmental risk. EPA argues that the data analysis indicates that certain industrial categories have a high potential for contributing to sediment contamination. The Metal Products and Finishing, Primary Metal Industries, and Industrial Organic Chemicals categories are ranked as industries with top sediment hazard potential. EPA's chemical review indicates that metals (cadmium, copper, nickel, lead, and zinc) and organic chemicals other than pesticides, PAHs, and PCBs constitute the most widespread potential sediment hazard from point sources. EPA contends that although the analysis does not imply that point sources caused the in-place contamination, it emphasizes the potential significance of contaminant releases in areas already contaminated.

According to the Contaminant Management Strategy, EPA intends to use the Source Inventory for monitoring, pollution prevention, effluent guideline development, total maximum daily load (TMDL) development, permitting, and enforcement purposes.

e. Total Maximum Daily Loads (TMDL)

According to the EPA's assistant administrator, Robert Perciasepe, EPA will "make sure that TMDLs are established for all listed waters, and that the load allocations established by TMDLs are implemented by point and nonpoint sources alike".

EPA defines the TMDL process as follows: States identify specific waters in which problems exist or are expected; States set priorities; State allocate pollutant loading among point and nonpoint sources; and EPA approves State actions or acts in lieu of the State, if necessary. Point and nonpoint sources then reduce pollutants to achieve the pollutant loading established by the TMDL through a wide variety of Federal, State, Tribal, and local authorities, programs, and initiatives.

EPA and States intend to use the Source Inventory as a screening tool to identify contaminant sources and possibly distinguish between point source and nonpoint source loadings. In Addition, when sediment quality-based standards exist in a State's water quality standards program, EPA and the State will use the Source Inventory to identify waterbodies that may not attain these standards. EPA will encourage States to modify or develop their own erosion and sediment control legislation to include consideration of toxics. EPA and States are in the process of developing TMDLs for waterbodies that are water quality limited.

f. NPDES Permitting

Through the NPDES permitting program, EPA and State regulatory agencies establish water quality-based pollutant concentration limits on the effluent of individual discharge facilities and monitor compliance with those limits. However, because of the lack of published chemical-specific sediment quality criteria and the very recent development of sediment bioassay methods, most NPDES permits do not contain limits specifically develop for sediment. EPA and States will develop water quality-based permit limits for targeted discharges to attain water quality standards and to protect sediment quality. EPA and States will use the Source Inventory as a screening tool to identify current point and nonpoint sources of contaminants nearby or upstream from contaminated, further assess and develop water quality-based permit limits to protect the sediment, and identify pollutants contributing to sediment quality problems.

EPA is currently developing *Technical Document: Models for Sediment Quality-Based NPDES Permitting*. This document will describe the technical aspects of applying existing hydrodynamic/water quality models for the development of sediment quality-based NPDES permits. The document contains underlying theory, model classification, and applications to different environmental settings. The draft document is scheduled for release in 1999.

g. Standardization of Test Methods for Sediment

In April 1995, EPA released the document, *QA/QC Guidance for Sampling and Analysis of Sediments, Water, and Tissue for Dredged Material Evaluations – Chemical Evaluations (EPA 823-B-95-001).* The document was prepared in response to regional requests for quality assurance and quality control (QA/QC) guidance associated with the testing and evaluation of proposed dredged material discharges into inland or ocean waters. The document pertains largely to physical and chemical evaluations.

The purposes of the QA/QC document are: to provide guidance on the development of quality assurance project plans for ensuring the reliability of data gathered to evaluate dredged material proposed for discharge under the Clean Water Act or the Marine, Protection, Research, and Sanctuaries Act (MPRSA); to outline procedures that should be followed when sampling and analyzing sediments, water, and tissues; and, to provide recommended target detection limits for chemicals of concern.

EPA and US Army Corps of Engineers' technical guidance for evaluating the potential impacts associated with the discharge of dredged material into inland and ocean waters is found in the documents, *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. – Testing Manual* (the Inland Testing manual, EPA 823-F-98-005) and *Evaluation of Dredged Material Proposed for Ocean Disposal – Testing Manual* (the Ocean Testing Manual, EPA 503-8-91-001). The QA/QC guidance document serves as a companion document to the Inland and Ocean Testing manuals.

Although the QA/QC guidance document is directed primarily toward the evaluation of dredged materials for aquatic disposal, the document may also be used in other areas of dredged material assessment and management (e.g., disposal site monitoring or evaluation of alternative disposal options).

The Inland Testing Manual, released in 1998, contains technical guidance for determining the potential for contaminant-related impacts associated with the discharge of dredged material in inland waters, near coastal waters, and surrounding environs through chemical, physical, and biological evaluations.

The Ocean Testing Manual, revised in 1991, evaluates potential contaminant-related impacts associated with the discharge of dredged material in the ocean. The manual contains technical guidance for determining the suitability of dredged material for ocean disposal through chemical, physical, and biological evaluations. The manual is applicable to all activities involving the transportation of dredged material for the purpose of dumping in ocean waters.

Additional documents pertaining to standardization of test methods for sediment are still pending. *Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment: Status and Needs* will provide guidance on the use of equilibrium partitioning sediment guidelines (ESGs) in water quality standards, TMDL development, NPDES permitting, SUPERFUND, and RCRA programs. The final document is scheduled for release in the summer of 1999.

Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates is a second edition of the 1994 freshwater standard sediment test methods manual. This manual will include updates of the two short-term standard freshwater sediment toxicity test methods and the standard bioaccumulation method published in 1994 and two new long-term sediment toxicity test methods for chironomus tentans and Hyalella azteca. The final document is scheduled for release in summer 1999.

Methods for Assessing Chronic Toxicity to of Marine and Estuarine Sediment-Associated Contaminants with the Amphipod Leptocheirus plumulosus is a joint EPA/US Army corps of Engineers publication. The document will contain a standard 28-day marine and estuarine sediment toxicity test method using Leptocheirus plumulosus with endpoints for survival, growth, and reproduction. The final document is anticipated for December 1999 release.

Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analysis will describe the EPA standard protocols and procedures for sediment sampling. The final document is scheduled for release in December 1999.

4. Shipyard Operations & Sediment Management Practices

A survey of US shipyards that were engaged in ship construction or repair activities was conducted in late 1997. The survey was developed to assemble data on shipyards' past, present, or anticipated future sediment management practices and to determine evaluate the relationship between site specific contamination and the objectives established in the *Contaminated Sediment Management Strategy*. A copy of the survey and a summary of the results are included in Appendix 2.

Eight new construction and repair shipyards participated in the survey for their sediment management and dredging practices. The eight shipyards that participated in the survey were:

- Atlantic Marine – Mobile, AL
- Avondale
- Bath Iron Works
- Electric Boat
- NASSCO
- Newport News
- Puget Sound Naval Shipyards
- Todd Pacific Shipyards

There was considerable variability in monitoring for sediment quality that was required of shipyards in the United States. As of November 1997, only three shipyards were required by regulatory agencies to monitor sediment quality for contaminants. The sediment analyses were required for contaminants including metals, pesticides, semi-volatiles, PCB, trybutyl tin (TBT), PAH. Bioassay and paint chip analysis were also required by regulatory agencies. One shipyard was required by Navy to monitor for radionucli. The three shipyards were in the process of conducting further investigation of their sediment quality for remedial activities. For these three shipyards, **copper**, **zinc**, **mercury**, **TBT**, and **PCB** were contaminants of concern.

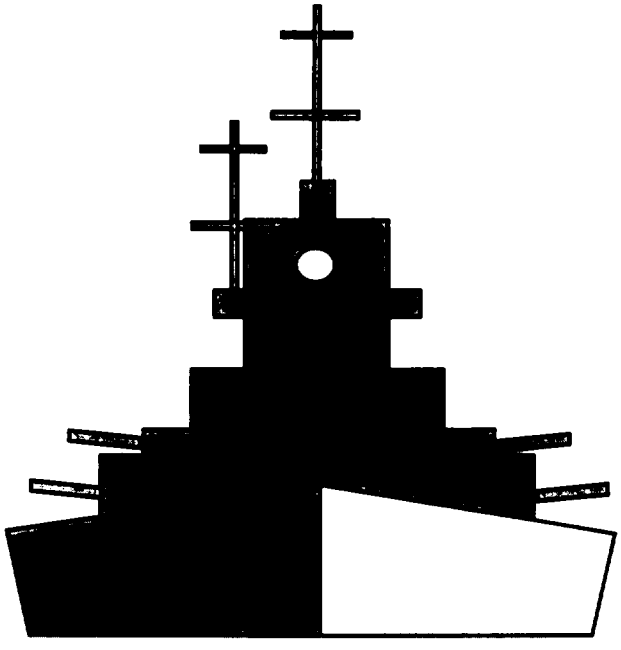
All, except for one, shipyards had engaged in dredging operation in the past 10 years. Most dredging activities took place as a part of yard maintenance practices. One shipyard's dredged material was analyzed for contaminants and found to contain copper and zinc in levels requiring disposal as hazardous waste. Most shipyards were able to dispose of dredged sediments without performing treatments. De-watering of sediment was the extent of treatment that was necessary prior to upland disposal. Although one yard did ocean disposal and another did disposal in river, most shipyards chose upland disposal as the primary disposal method.

Various activities occurred at shipyards that may have a bearing on the types and quantities of contaminants that can be transported to sediment. All eight shipyards performed welding, painting, blasting, and various cleaning operations in- and outdoors. Use of zinc-based primers and copper-based marine topcoats were prevalent in all shipyards. Also, the use of various blasting media, including copper slag, steel shot, and coal slag, was found in every shipyard. The abundance of zinc containing materials, including welding rods, anodes, and paint, was common at all eight shipyards. All shipyards conducted one or more form of cleaning operations. Most cleaning operations entailed the use of various organic solvents.

The shipyard survey revealed an interesting, perhaps alarming, phenomenon. Although the use of PCB, mercury, and TBT containing materials at shipyards have been curtailed dramatically in the past decade, the shipyards that were required to perform sediment monitoring still encountered traces of the above constituents in their sediment samples. Whether the contaminants were from historical practices using materials containing the above constituents or performing operations, such as blasting and painting, that generated those contaminants to settle into the underlying sediment via storm water or direct discharges, or caused by natural movement of sediment carrying contaminants from off-site, those shipyards were faced with possible remediation of contaminated sediment. Should other shipyards be required to monitor the sediment underlying their facilities, the number of shipyards that will have to mitigate will likely to increase.

The use of metal containing materials, operations that generate particulate matters containing copper, zinc, and other metals, and operations that use hydrocarbon are likely point source targets that will be regulated to meet the objectives outlined in the Contaminated Sediment Strategy. The development of TMDL for waterbodies, numerical discharge limits for NPDES permits, and equilibrium partitioning sediment guidelines (ESG) will most likely to impact the way shipyards use materials and perform activities that contain metals and hydrocarbon constituents.

II. Risk Management



II. Risk Management

This section illustrates how shipyards can make decisions with regard to managing contaminated sediments. Traditionally, contaminated sediments had been most closely regulated by the Office of Marine and Estuarine Protection (OMEP) under the Marine Protection, Research, and Sanctuaries Act (MPRSA) for ocean dumping and the Office of Wetlands Protection (OWP) for dredge and fill activities under the Clean Water Act (CWA). In recent years, however, it has become increasingly apparent that the scope of the contaminated sediment problem extends far beyond this traditional context. A more comprehensive management program strategy has been developed by the U.S. EPA to address the range of contaminated sediment issues.

The information included herein is excerpted from the EPA document *Managing Contaminated Sediments: EPA Decision-Making Processes, EPA 506-6-90-002* that was published in December 1990. This document provides useful information that shipyards can use in their decision-making processes on managing contaminated sediment.

The information in section is divided into six sub-sections as follows:

- Finding Contaminated Sediments – Identification and monitoring
- Assessment of Contaminated Sediments – Determining the effects of sediment contamination
- Prevention and Source Control – Reducing and preventing sediment contamination
- Remediation – Determining when, how, and to what degree the contaminated sediments should be remediated
- Treatment of Removed Sediments – Determining when and how removed sediments need to be treated before disposal
- Disposal of Removed Sediments – Selecting appropriate disposal methods and locations for removed contaminated sediments

The Figure 1 outlines the major options for controlling sediment contamination. There are two major entry points to the selection of options: 1) when contaminated sediments are suspected, and 2) when dredging must occur. At each decision point, there are generally one or more options for taking action and a no-action alternative. If contaminated sediments are encountered, the only action that a shipyard may be required take is reducing contaminant sources. However, other options can be exercised if they are necessary to obtain acceptable sediment quality.

Finding Contaminated Sediments

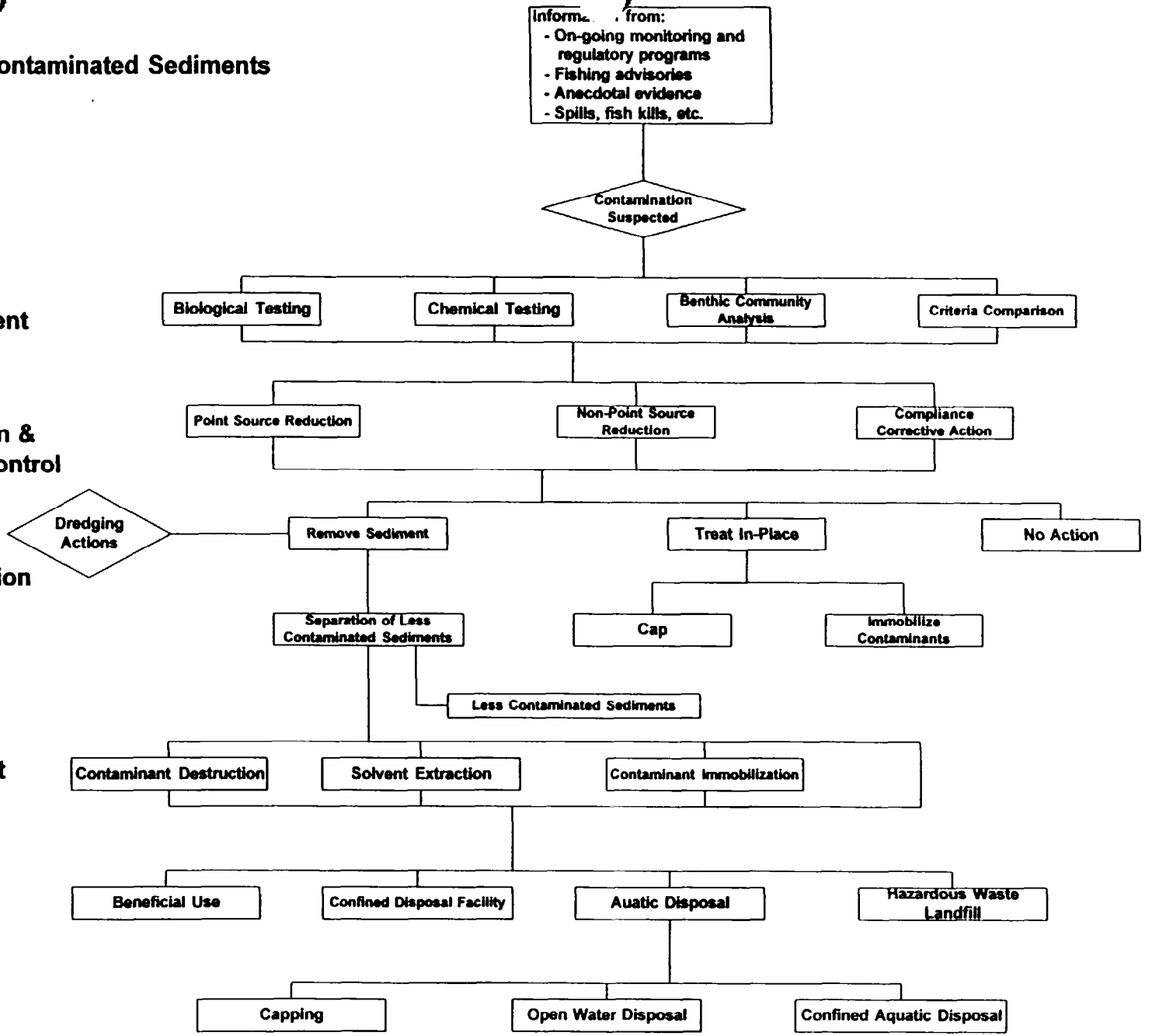


Figure 1. Options for Controlling Sediment Contamination

1. Finding Contaminated Sediments

Before initiating a full-scale, potentially costly sediment assessment program, a shipyard should attempt an initial identification of areas containing probable contamination problems. The contamination of sediment is a process influenced by a number of variables including contaminant source, contaminant type, sedimentary and hydrologic environment, sediment grain size distribution and composition, presence and type of aquatic life, and historical influences.

The possibility of presence of a sediment contamination problem at a shipyard needs to be appraised based on readily available information. The information may be available from on-going monitoring or regulatory programs, previous site characterizations, dredging records, discharge permits, area maps, fishing advisories, report of spills, fish kills and beach closings, etc.

It is worth noting that sediment contamination problems need not be connected to poor water quality. The ability of sediment to retain contaminants over time makes it possible for sediments to remain contaminated while water column contaminant concentrations remain below applicable water quality standards.

2. Assessment of Contamination

When an initial screening indicates the possible presence of a sediment contamination problem at the site, the shipyard need more complete characterization of the sediment, including an assessment of the environmental threat posed by the contamination. In the selection of sediment assessment methods, the first consideration is determining what is to be protected. Assessment methods will vary in their ability to indicate effects on aquatic life, wildlife, or human health.

The simplest assessment approach is the direct comparison of observed concentrations of sediment contaminants to some pre-established criteria. As discussed in the earlier section of this Guide, EPA is in the process of developing the Equilibrium Partitioning Sediment Guidelines (ESGs). The equilibrium partitioning (EqP) approach is based on a simple model that describes the partitioning of a contaminant between sediment phases that bind the contaminant and interstitial water. The application and implementation of ESGs will be described in the document *Implementation Framework for Use of Equilibrium Partitioning Sediment Guidelines*, which is anticipated for release in fall 1999.

Shipyards can also use the reference approach for assessing sediment quality. In the reference approach, the sediment contaminant concentrations at a site are compared with background concentrations from "unaffected" sites from the same area. In addition, as discussed in the *Standardization of Test Methods for Sediment* of this Guide, EPA is in the process of developing various test methods for sediment that shipyard may be required to follow.

3. Prevention and Source Controls

When sediment contamination is found, it is imperative that the shipyard determines the cause of the problem. If, for example, continuing discharges are linked to sediment contamination, controls would be considered. On the other had, if a spill is the cause, source controls may have little effect on contamination levels. Upon identification, shipyard must consider technical and economical feasibility to prevent or control the contamination source.

As discussed earlier in this Guide, EPA finds the volume three of the 1997 Report to Congress, Source Inventory, useful to: identify sites where additional evaluation is necessary for a determination of adverse effects; identify industrial categories potentially contributing sediment contaminants to surface waters; and select industries for the development of effluent guidelines on the basis of quantities of potentially toxic sediment contaminants discharged. According to the Contaminant Management Strategy, EPA intends to use the Source Inventory for monitoring, pollution prevention, effluent guideline development, total maximum daily load (TMDL) development, permitting, and enforcement purposes. In addition, EPA has the authority under various statutes (CWA. TSCA, FIFRA, CAA, RCRA, and CERCLA) to require shipyards to take corrective actions to prevent further contributions of contaminants to sediments.

4. Remediation

Contaminated sediments have not been frequently remediated due to:

- The lack of a clear regulatory and programmatic avenue to accomplish remediation;
- The generally high costs of remediation; and
- The lack of established criteria for determining action and cleanup levels.

EPA stresses that sediments should be remediated when "acceptable" environmental quality will not be achieved by natural processes within a "reasonable" period of time. However, both "acceptable" and "reasonable" have not been defined in practical or operational terms. When working with regulatory agencies on remediating contaminated sediments, the shipyard should pose the following questions to itself and the agencies for consideration:

- Will contaminated sediment be sufficiently covered over by clean, natural sediment or naturally degrade within a reasonable time frame?

- Will covered sediments be released by storms or other mechanisms/

- Have sources been controlled sufficiently that significant sediment contamination will not recur if remediation is undertaken?

- Can the contaminated sediment be spread if left unremediated?

- Are there technically and economically feasible alternatives for remediation?

- Are adverse environmental, human health, and beneficial use impairments severe enough to warrant remediation?

- Will the positive long-term benefits of remediation outweigh the possible negative short-term impacts of the action?

There are three general sediment remediation options
- Take no action and let natural sedimentation cover over contaminated sediments
- Treat contaminated sediments in-place
- Remove contaminated sediments to another area with or without treatment

For any given site, however, a combination of options may be appropriate. Depending on the considerations listed below, sediments in one part of a site may be removed, while treatment in-place or no action may be appropriate for other parts. Which options to choose are site- or locality-specific and may depend on the resources available and potential disposal options.

In general, the expected environmental benefits, possible adverse impacts, the time frame for natural recovery, and the feasibility and cost of various treatment and removal options are the major determinants in selecting options for a particular location.

Questions that need to be answered at this level include:
- How long would it take for the sediments to recover naturally to acceptable levels?
- Must the contaminated area be dredged for navigational purposes?
- Will the remedial action option significantly alter the hydrology or habitat of the area?
- Will the remedial action option be sufficiently permanent to warrant the expense (i.e., will a cap be eroded by currents or waves)?
- What are the relative costs of dredging and disposal versus treatment in-place?
- What are relative environmental risks and benefits of the alternatives?

The "No-Action" option is most viable if one of the following situations exists:

- The sources of sediment contamination have not yet been significantly reduced, eliminated, or controlled. Taking remedial action in this case is not effective because the sediments would soon be re-contaminated. The most prudent action is to control the sources before undertaking any remedial action on the contaminated sediments. An exception exists where sediments pose a threat of becoming a source of further contamination of downstream area or groundwater;

- The sources of sediment contamination have be eliminated or controlled; and, the contaminated sediments are in a low energy, non-erosive environment that will not be disturbed by dredging or construction activities or by natural means such as storms. In this case, a natural cap of clean sediment is being formed over the contaminated sediments, therefore, reducing or eliminating the transfer of pollutants from the sediments to the overlying water and biota; OR

- The sources of sediment contamination have been eliminated or controlled; and, remedial action is desirable. However, taking remedial action would be more environmentally damaging than leaving the contaminated sediment in-place untreated.

In general, "IN-Place Treatment" is appropriate if ALL three of the following conditions apply:

- The sediments are in a low energy, non-erosive environment. After in-place treatment, the treated sediments will remain undisturbed by natural forces;

- The sediments will not be disturbed by dredging or construction activities. Such activities could render the in-place treatment ineffective by re-exposing contaminated sediments or by breaching an established barrier. Alternatively, the treatments could make dredging or construction very difficult (e.g., if the sediments were solidified into concrete); AND

- The in-place sediments do not act as a source for contamination of other media, such as groundwater.

Possible in-place treatments include: immobilizing the sediments and contaminants by treating with fixatives to solidify or otherwise reduce bioavailability; treating with neutralizers or binders to make the pollutants less bioavailable; and covering sediments with barriers or sorbents to reduce transfer of pollutants from sediment to the water column and biota (e.g., capping).

The "Sediment Removal" option is viable if:

- The removal and disposal/treatment can be done so as to prevent unacceptable adverse impacts from reoccurring;
- Sediment removal is necessary for navigation or construction purposes; or
- Viable disposal options exist.

If the decision to take action, either treatment or removal, is made, then the shipyard needs to make technical considerations before choosing a specific technique:

- Will the sediments support the weight of a cap?
- Will a cap have sufficient integrity to prevent its erosion by currents or waves?
- Will a cap significantly alter the location or speed of currents in the area?
- Will a cap sufficiently prevent the migration of contaminants to the surface and the effects of bioturbation?
- Will contaminated sediments be a contaminant source to groundwater?
- Will mixing in the solidification agents cause significant releases of re-suspended contaminated sediments?
- What are the relative costs of feasible capping or treatment alternatives?
- To what extent does the alternative permanently isolate contaminated sediments from the environment?

Removal options consist mainly of conventional dredging and excavation techniques. The shipyard needs to address the following question when selecting removal options:

- What are the physical and chemical characteristics of the sediments to be dredged?
- What are the physical constraints at the dredging site or for access to the dredging site?
- What is the water depth at the site?
- What losses or re-suspension of contaminants from the removal operation are acceptable?
- Is equipment available that will meet the minimum loss rate requirements and what are their relative costs?
- If the minimum loss rates cannot be achieved, what other measures can be taken to mitigate impacts (e.g., silt curtains, cofferdams, downstream sediment traps, etc.)?

5. Treatment Options

If sediment removal is undertaken primarily to reduce the environmental or human health risk of leaving the sediments in-place, the sediments removed are more likely to be contaminated than those removed by most navigational dredging. Thus, some degree of treatment may be required before disposal at the disposal facilities.

a. Contaminant/Sediment Volume Reduction

This can be used in conjunction with other treatments and involves reducing the total volume of contaminated sediment through mechanical separation of the finer sediment from the coarser sand gravel that is generally less contaminated. Examples are hydrocyclones and soil-washing processes. Treatment can then concentrate on the more contaminated fine material. If contaminant levels are low enough, the coarse material may be employed for beneficial uses (e.g., construction fill material). Thermal processes may also reduce sediment volumes through loss of organic and volatile materials at high temperature.

b. Contaminant Immobilization

This involves mixing the sediment with materials that either bind strongly to the contaminants to prevent their leaching or solidify the dredged material into essentially unleachable solids. Solidifying agents such as Portland cement can be used. Sediment may also be mixed with siliceous hardening agents such as fly ash or blast furnace slag and hardened into blocks or into a soil-like material. Calcium carbonate has been used to bind to metals and increase the pH of runoff from dewatered dredged material; thus, effectively treating the metals in runoff from sediments placed in confined disposal facilities.

c. Contaminant Destruction

Contaminant destruction technologies include biodegradation, chemical detoxification, and thermal techniques. Most are appropriate for dealing with organic contaminants. In general, processes that are designed for dealing with one type of contaminant can be made less effective by the presence of the other type. Vitrification, fluidized bed reactor incineration, metal dechlorination are among the technologies that are being more evaluated. Heat-related processes are all relatively expensive.

d. Contaminant Extraction

Extraction technologies remove contaminants from sediments by partitioning them in an appropriate extractant. In general, they are much cheaper than thermal technologies, and have been more widely applied in hazardous waste cleanups. Triethylamine (TEA), methanol, acetone, liquid propane, or aqueous acids are used as solvents. Few solvent extraction technologies remove both organic and inorganic contaminants.

e. Thermal Separation

Physical mass and contaminant quantities in sediments can sometimes be reduced by low temperature (200-1000 degrees F) thermal treatment. Thermal separation is most effective for the removal of volatile and semi-volatile organics and volatile metals, and the destruction of cyanides. This process works best for sediments with relatively low water and organic carbon content.

The above processes may require modification of the sediments before treatment. For instance, most processes require that sediments be dewatered to some extent. Before choosing any of the above technologies, however, the shipyard needs to consider the following:

- Are the sediments so highly contaminated that they must be treated no matter how they are to be dispose?
- Will treatment open up disposal options that were otherwise not available because of unacceptable environmental risks?
- Will the benefits of using the newly available disposal option offset the additional costs of treatment (and disposal of any additional wastes generated)?
- Are the sediment contaminants primarily organic or inorganic?
- Are the organic contaminants all soluble in the same solvent?
- Are most inorganic contaminants likely to be removed by acid extraction?
- Will side effects such as volatilization be increased or diminished?
- Are the binding agents that combine with the contaminants or the extractants compatible with the sediment matrix or other contaminants?
- Is there a commercial-scale system available?
- What is the cost of treatment relative to the available funds?

It can be inferred from the information needs that most treatment methods work well for either organic or inorganic contaminants only. While this is generally the case, certain combination of specific organic and inorganic contaminants my be extractable with the same processes (e.g., the TEA process).

6. Disposal Options

Whether the contaminated sediments were treatment and the success of the treatment process have a great influence on the disposal options available for the remaining sediment. To determine the disposal options, the characteristics of the contaminated sediments (treated or untreated) must be compared to the criteria specified under various environmental statutes. The basic disposal options for contaminated sediments are:

a. Unconfined Aquatic Disposal

This option is usually reserved for uncontaminated sediments. However, it can also be applicable if the sediments can be rendered inert by treatment.

b. Beneficial Uses

This option is applicable to minimally contaminated or uncontaminated sediments. Beneficial uses include beach nourishment and construction fill.

c. Confined Aquatic Disposal (CAD)

This option consists of using clean sediments to cover over contaminated sediments that were disposed of at an aquatic site. This option is viable if the site is one of low energy so that the cap is not eroded. The cap has to be of sufficient thickness to prevent disturbance of the cap by burrowing aquatic organisms and possible contaminant migration through the cap. The possibility of contaminant migration into groundwater should be minimized.

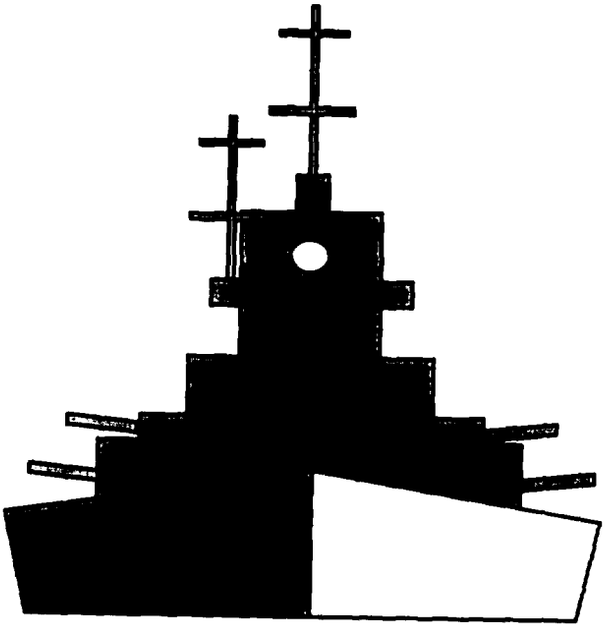
d. Confined Disposal Facility (CDF) Disposal

This option consists of constructing an in-water dike to separate a portion of a nearshore area from surrounding waters. CDFs are frequently constructed with part of the perimeter being an existing breakwater or land area, although thy are sometimes constructed to be man-made islands. Contaminated sediments are deposited within this diked area. The dike walls can be constructed of a variety of materials having different permeability. CDFs can lose contaminants through discharges through the dike walls or through supernatant-decanting weirs or discharge structures. These losses can be reduced through the use of liners or systems to collect and treat leachate. CDFs may be suitable for moderately to highly contaminated sediment if the appropriate design features are incorporated to keep pollutant emissions to acceptably low rates.

e. Upland Facilities

This option consists of a disposal facility resembling a landfill or waste disposal facility. It can be constructed to various degrees of contaminant isolation through the use of different materials for the walls, using additional liners, installing leachate collection layers, etc. This option can be suitable for moderately to highly contaminated sediments if the appropriate design features are incorporated to keep pollutant emissions at acceptable low rates.

III. Assessment, Removal, & Treatment Technologies



III. Assessment, Removal & Treatment Technologies

In the past 20 years, toxic discharges into the rivers, harbors, bays, and Great Lakes have been declining; however, persistent contaminants in sediments continue to pose a potential risk to both the environment and to human health. New technologies are currently being developed to help remove and treat contaminated sediment that will in turn reduce the risks to humans, wildlife, and aquatic organisms.

This section of the guide reviews the techniques and technologies available for the assessment, removal, and treatment of contaminated sediment. The appendices 3 through 5 contain assessment, removal, and treatment technologies, respectively.

1. Assessment Technologies

Assessment Technologies (**Appendix 3**) is divided into three sub-sections:

- Sediment Sampling Surveys
- Sediment Toxicity Assessment
- Procedures for Characterization of Contaminated Sediments

The information on sediment sampling surveys came from the *Assessment Guidance Document (EPA 905-B94-002 August 1994)* prepared by the Toxicity/Chemistry Work Group as part of the Assessment and Remediation of Contaminated Sediment (ARCS) Program administered by the U.S. Environmental Protection Agency's (USEPA) Great Lakes National Program Office. The information on sediment toxicity assessment and procedures for characterization of contaminated sediment came from the *Remediation of Contaminated Sediments – Handbook (EPA 625/6-91/028 April 1991)* prepared by the Center for Environmental Research Information – Office of Research and Development for the USEPA.

2. Removal Technologies

Removal Technologies (**Appendix 4**) includes summaries of 49 different removal technologies. The index of removal technologies in alphabetical order precedes the summaries in Appendix 4. Five different categories of removal technologies make up the summaries. The five removal technology categories are:

- Mechanical
- Hydraulic
- Fluidization
- Pneumatic
- Miscellaneous

The removal technology summaries include the following information when available: the name and type of removal technology; a description of the technology; the water depth in which the removal system will work and whether debris affects the system; the current developmental stage of the technology; system limitations; environmental concerns; removal rate; capital cost and unit cost estimates; literature references; list of contacts for the developers and vendors; and, case histories using the removal system.

SEDTEC™ was used for compiling the removal technology information. SEDTEC ™ is a directory of contaminated sediment removal and treatment technologies. The directory was compiled by Environment Canada and is currently available on CD-ROM. The SEDTEC ™ CD-ROM is compatible with Windows 3.1 or Windows 95 and requires eight MB of memory. The removal technology summaries presented in Appendix 4 are hard copies of the data presented in the SEDTEC ™ database.

3. Treatment Technologies

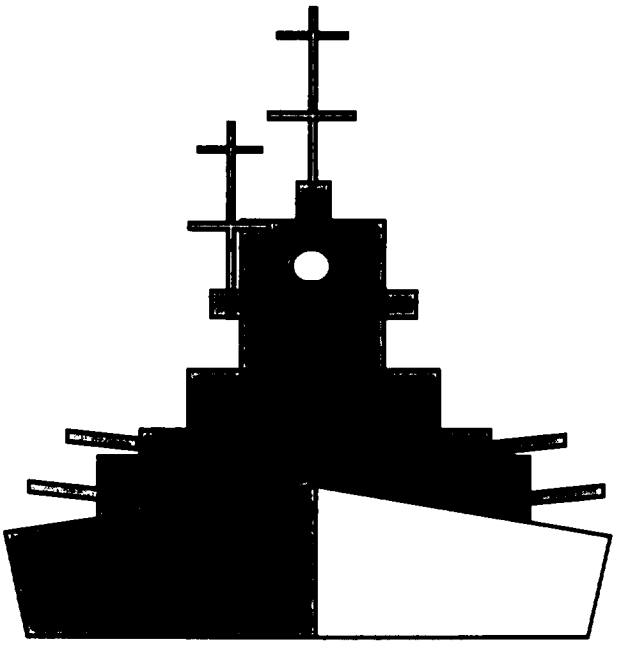
Treatment Technologies (**Appendix 5**) includes summaries of 189 different treatment technologies. The index of treatment technologies in alphabetical order precedes the summaries in Appendix 5. Twelve different categories of treatment technologies make up the summaries. The twelve treatment technology categories are:

- Thermal
- Stabilization/Fixation
- Soil Washing/Volume Reduction
- Pre-Treatment
- Post-Treatment
- Organic Extraction
- Metal Extraction
- Incineration
- Chemical
- Physical
- Biological
- Electrokinetic, Vitrification, and Miscellaneous

The treatment technology summaries include the following information when available: the name and type of treatment technology; a description of the technology; the treatment efficiency; the type of media treated; the current developmental stage of the technology; system limitations; environmental concerns; setup and feed rate; emissions and byproducts; capital cost and unit cost estimates; literature references; list of contacts for the developers and vendors; and, case histories using the treatment system.

SEDTEC™ was used for compiling the treatment technology information. SEDTEC ™ is a directory of contaminated sediment removal and treatment technologies. The directory was compiled by Environment Canada and is currently available on CD-ROM. The SEDTEC ™ CD-ROM is compatible with Windows 3.1 or Windows 95 and requires eight MB of memory. The treatment technology summaries presented in Appendix 5 are hard copies of the data presented in the SEDTEC ™ database.

IV. Case Studies



IV. Case Studies

1. Seventh Street Channel/Paleta Creek, Naval Station - San Diego Bay, California

Approximately three acres of the Seventh Street Channel and the Paleta Creek has been identified to be contaminated with the pesticides chlordane and DDT, and PAHs from fossil fuels that can cause degraded benthic communities. The Regional Water Quality Control Board, San Diego Region (RWQCB) conducted the assessment of this site during the period 1992 to 1994 as a part of the State of California's effort to cleanup the State's "toxic hot spots". RWQCB identifies Navy, passing ship traffic, and businesses and residences tributary to Paleta Creek as potential dischargers of pollutants. Possible activities that could have resulted in discharges of chemical waste include ship refueling and bilge pumping (PAHs and petroleum hydrocarbons), direct disposal of industrial wastes, urban runoffs from the watershed containing pesticides from lawns, streets, and buildings, and termite and insect control runoff from pest control operations.

RWQCB identifies clamshell dredging and hydraulic dredging followed by an upland disposal as one of the options. The other proposed option involves dredging a disposal site at another location in San Diego Bay, depositing the contaminated dredge spoil from the Seventh Street Channel, and capping the site with clean sand.

The RWQCB's preliminary cost analysis is based on the 1997 cost schedule. RWQCB estimates that 14,520 square yards (three acres) need remediation and that sediment to a depth of one yard would have to be removed. For upland disposal, the 14,520 cubic yards of dredge spoil would then be placed on a barge, unloaded onto trucks, and transported to a suitable upland landfill or to a Class III disposal site. The following table shows the high and lost costs for dredging and upland disposal of 14,520 cubic yards of spoil:

Table 1. Comparison of High & Low Costs for Dredging and Upland Disposal

High Cost per Cubic Yard		**Low Cost per Cubic Yard**	
Clamshell Dredging	$10	Clamshell Dredging	$10
Unloading from Barge	TBD	Unloading from Barge	TBD
Transport by Truck	$200	Transport by Truck	$200
Disposal at Class I Site	$300	Disposal at Class III Site	$30
Sub Total per Cubic Yard	$510	Sub Total per Cubic Yard	$240
14,520 Cubic Yards x $510 = **$7,405,200** (Not Including Permits)		14,520 Cubic Yards x $240 = **$3,384,800** (Not Including Permits)	

For dredging and contained aquatic disposal, RWQCB estimates the same amount of sediment to be dredged. An aquatic disposal site also would have to be dredged and clean sand to be obtained for use as a cap. Another suitable cap to prevent burrowing animals from penetrating the cap would have to be provided as well. The 14,520 cubic yards of dredge spoil would be placed on a barge and transported to the aquatic disposal site. The cap would then be constructed. For the purpose of low cost analysis, it is assumed that confinement at the disposal site is not necessary. The following table shows the high and low cost for dredging and contained aquatic disposal.

Table 2. Comparison of High & Low Costs for Dredging & Contained Aquatic Disposal

High Cost per Cubic Yard		**Low Cost per Cubic Yard**	
Excavation of Disposal Site	TBD		
Clamshell Dredging	$10	Clamshell Dredging (Assuming Confined Disposal is Not Needed)	$10
Barge Transport of Waste (Assume High Truck Costs)	TBD		
Disposal at Aquatic Site	$9		
Cap at Disposal Site	TBD		
Monitoring at Disposal site	TBD		
Sub Total per Cubic Yard	$19	Sub Total per Cubic Yard	$10
14,520 Cubic Yards x $19 = **$275,880** (Not Including Creating and Maintaining Disposal Site or Acquiring Permits)		14,520 Cubic Yards x $10 = **$145,520** (Assuming a Confined Site is Not Needed)	

RWQCB has made no attempt to ask potential responsible parties for participating in any remediation activities. Thus, the estimates shown are based on conjecture. This information is provided in the RWQCB's *Draft Regional Toxic Hot Spot Cleanup Plan* dated November 8, 1998.

2. National Steel and Shipbuilding Company (NASSCO) - San Diego, California

In 1991, the California Regional Water Quality Control Board, San Diego Region (RWQCB) informed NASSCO of concerns regarding the possible presence of elevated chemical concentrations in sediments within NASSCO's leasehold in San Diego Bay. Pursuant to this notification, NASSCO conducted activities necessary to determine appropriate indicator chemicals to use when evaluating sediment quality and identified appropriate cleanup levels for these chemicals.

The results of preliminary assessment of sediments within the NASSCO leasehold using nine NPDES sediment sampling events, which were conducted between December 1992 and December 1996, indicated that the average copper and/or zinc concentrations exceeded the selected cleanup levels at five locations. The five locations coincided with areas where either ship repair or construction and launching into San Diego Bay took place or were in the vicinity of a storm water outfall. The cleanup levels chosen were developed for the nearby Campbell Shipyard in 1990.

Following completion of assessment activities, RWQCB issued a directive in 1997 to NASSCO requiring that NASSCO conduct additional sediment investigations within its leasehold. The directive specifically required NASSCO to conduct site sediment investigations to determine the areal extent of the elevated concentration of copper and zinc in sediments and to determine the necessity for and extent of remedial action.

Pursuant to RWQCB's request, NASSCO conducted an additional surficial and core sediment analyses for copper, zinc, and mercury. No additional surficial contamination above 810 mg/kg, 4,2 mg/kg, and 820 mg/kg for copper, mercury, and zinc, respectively, was found. Core mercury levels at one location 1.5 to 3.5 ft below the bay bottom showed the level above 4.2 mg/kg.

NASSCO identified four discrete areas as appropriate for remediation within the NASSCO leasehold. Compiled data indicated that sediment chemical concentrations continued to decrease when moving farther away from these areas of concern.

NASSCO is currently considering three methods of remedial alternatives for four areas of concern: 1) natural attenuation, 2) capping, and 3) dredging. Capping may be infeasible because it would not allow for the in-water depth that NASSCO requires to conduct its ship construction and repair activities. Should NASSCO choose dredging as the preferred remedial alternative, a total of approximately 11,418 cubic yards of sediment would be removed from the inner leasehold area. NASSCO expects that the dredged material would then be disposed of at a local upland site.

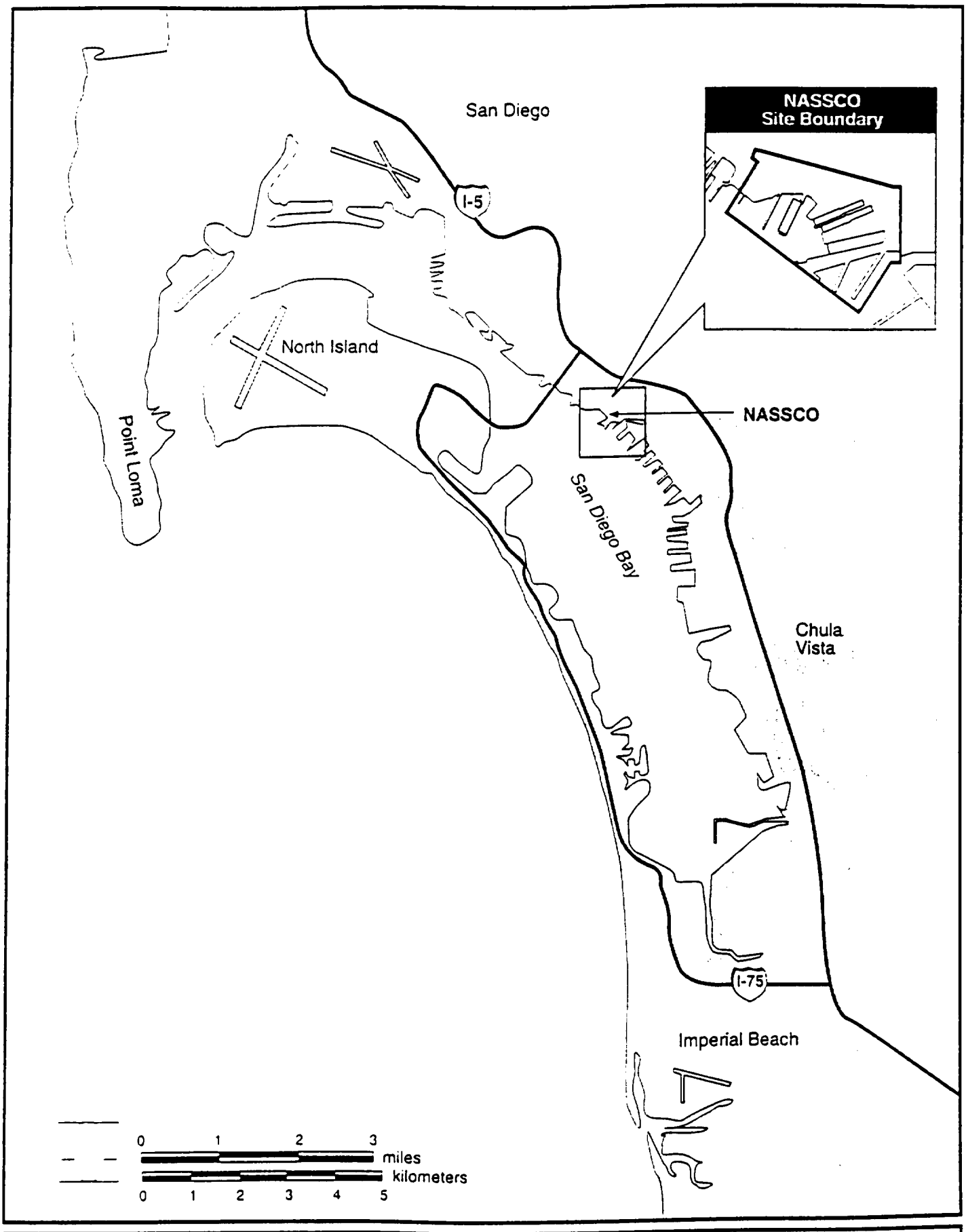


Figure 1. Location of the National Steel and Shipbuilding Company site.

If dredging is selected, post-remediation surface sediment sampling will be conducted to confirm that the copper and zinc cleanup levels have been achieved within the areas remediated.

3. Outboard Marine Corporation Superfund Site – Waukegan, Illinois

Outboard Marine Corporation (OMC), located on Lake Michigan, performed marine product manufacturing operation at the site. Contamination of the soil and sediments at the site resulted from the discharge of hydraulic fluid containing PCBs through floor drains that discharged to several areas at the site and into Waukegan Harbor. An estimated 700,000 pounds of PCBs were discharged to the OMC site and 300,000 pounds of PCBs were discharged to Waukegan Harbor. Based on a 1989 Consent Decree and Record of Decision, remedial activities selected for the site included excavation, stockpiling, and treatment of soil and sediment contaminated with PCBs. A cleanup goal for PCBs in soil and sediment of 97% removal was specified in the 1989 Record of Decision.

SoilTech's mobile Anaerobic Thermal Processor (ATP) system was selected for treating the PCB-contaminated soil and sediment at OMC. The ATP system was operated at the site from January 23, 1992 until June 23, 1992. During this time, 12,755 tons of PCB-contaminated soils and sediments were treated. The ATP system met the cleanup goal for PCBs in soil and sediment by achieving an average removal efficiency of 99.98% for total PCB concentrations. PCBs in treated soil ranged from 0.4 to 8.9 mg/kg. The PCB destruction and removal efficiency of 99.9999% and total dioxin and furan stack emission requirements of 30 ng/dscm were met during the cleanup.

During the proof-of-process period (January 23 through March 5), the destruction and removal efficiency for PCBs was not met; thus, EPA shut down the system. From March 5 through May 30, SoilTech made modifications to the system, and the stack gas emissions requirements were met during the remainder of the soil cleanup. An EPA site demonstration was conducted at the OMC site in June 1992. During this demonstration, 255 tons of soil and sediment were treated.

The total cost for the full-scale application of thermal desorption at the OMC site was $2,474,000. This was the actual total cost for cost elements directly associated with treatment, including solid preparation and handling, startup, testing, permits, operation, capital equipment, and demobilization. An additional $900,000 was spent for before-treatment costs involving mobilization, preparatory work, monitoring, sampling, testing, and analyses.

The thermal desorption system from SoilTech was a rotary kiln desorber with proprietary sand seals. The system had the retort zone temperature of 1,207 degrees Fahrenheit and the preheat and retort zone residence time of 30 – 40 minutes. The air emission were controlled using cyclones, baghouse, scrubbers, fractionator, condenser, gas-oil-water separator, and carbon adsorption. Water was treated on site using sand filtration, Klensorb® filtration, ultraviolet oxidation, cartridge filtration, and carbon adsorption.

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